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CONTROL OF COMMON WHITE GRUBS in CEREAL and FORAGE CROPS

FARMERS' BULLETIN No. 1798
U.S. DEPARTMENT OF AGRICULTURE

1938

WHITE GRUBS, the young of May beetles, frequently destroy large acreages of farm crops by eating the roots and other underground parts. The crops damaged or destroyed include timothy, bluegrass, and two of our most important staples, corn and potatoes. The adults—the beetles—eat the leaves of certain trees and shrubs and sometimes feed on common weeds.

Most of the especially injurious species have a 3-year life cycle, as shown in the pictorial diagram (fig. 13). An abundance of May beetles one year points to an abundance of grubs the following year.

Injury from white grubs can be controlled or reduced by correct farm practice. Practical directions for combating white grubs are given in this bulletin.

This is a revision of and supersedes Farmers' Bulletin 940, Common White Grubs.

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CONTROL OF COMMON WHITE GRUBS IN CEREAL AND FORAGE CROPS

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WHITE GRUBS, THE YOUNG OF MAY BEETLES

THE WHITE GRUBS, *Phyllophaga* spp., or grubworms (see title-page illustration and fig. 8), of which there are over 100 different species, are the young of the May beetles or June bugs. They feed on the roots of various plants and the tubers of the potato. For years

FIGURE 1.—Individual corn hill showing the effects of severe white grub injury.

they have been recognized as serious pests of corn (figs. 1 and 2) and timothy, and, to a lesser extent, of strawberries and potatoes, recently transplanted roses, and nursery plantings, particularly conifers. The adult insects (the beetles) (fig. 3) eat the leaves of oak, ash, hickory,

poplar, elm, willow, locust, hackberry, pine, walnut, and other trees, and when abundant sometimes completely strip tracts of timber (fig. 10). They feed also on herbaceous plants, particularly weeds, such as curly dock, cinquefoil, and wild sunflower. Although as a rule adults of different species show a preference for different food plants, their grubs do not appear to have different food habits. Small grains are less attacked and injured by grubs than are corn, timothy, strawberries, beans, potatoes, and conifer seedlings.

ECONOMIC IMPORTANCE OF WHITE GRUBS

From information derived from surveys of infested regions and reports from farmers and others it has been estimated that during years of heavy infestation damage to corn, timothy, and potatoes in the

FIGURE 2.—A cornfield injured by white grubs.

North Central States alone exceeds several million dollars. When such infestations occur it is not unusual to find from 12 to 17 grubs in a single hill of corn, and this often results in a complete loss of the crop. In recent years white grubs have become increasingly important as enemies of trees in nurseries.

HISTORY OF OUTBREAKS

The most serious outbreaks of white grubs recorded in the history of American agriculture occurred in 1912 and 1915, following an abundance of May beetles in 1911 and 1914, respectively. Injury was reported from almost every section of the country north of the Ohio River and westward to South Dakota. White grubs have continued to be serious pests every third year over approximately the same region. In 1927 the area of severe infestation increased in the Middle West, especially in northern Illinois and Indiana, and apparently decreased

in the Eastern States. In 1933 corn, meadows (fig. 4), and lawns were seriously injured in parts of Iowa, Wisconsin, Illinois, Indiana, and Minnesota. These same general areas were again affected to a lesser extent in 1936.

POSSIBILITIES OF OUTBREAKS IN THE FUTURE

As May beetles were unusually abundant in 1908, and as the grubs have caused much damage, beginning with 1909, in Wisconsin, Illinois,

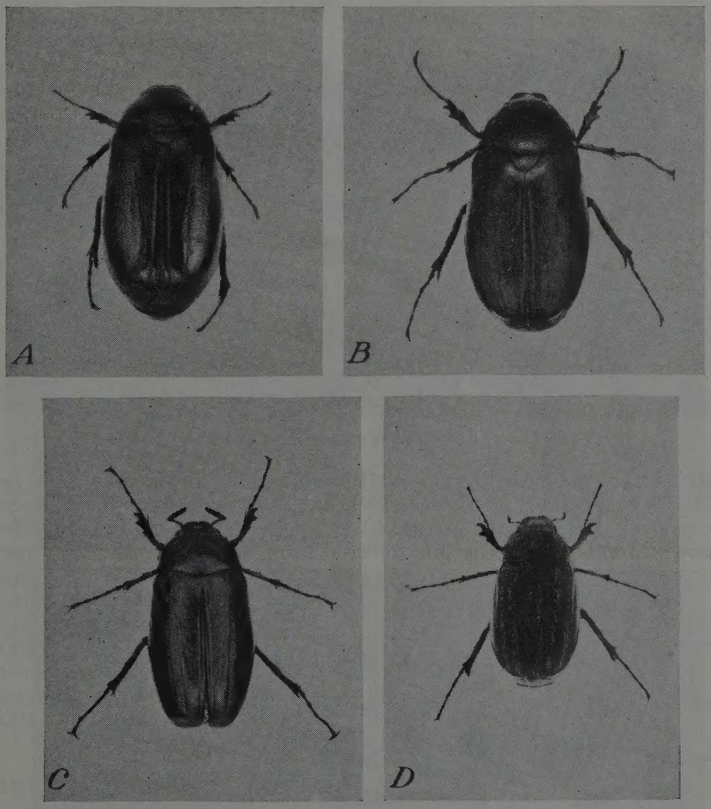

FIGURE 3.—May beetles representing four of the most destructive species of white grubs: *A, Phyllophaga fervida; B, P. anxia; C, P. fusca; D, P. hirticula.* One and one-half times natural size.

and other States every third year since then, outbreaks of more or less severity in these regions may be expected in the future every third year, beginning in 1939. This is borne out by this Bureau's life-history studies of caged insects, which furnish conclusive evidence that in these localities the life cycle of most of the more abundant and injurious species is uniformly 3 years.[1]

[1] *Phyllophaga tristis* has a 2-year cycle. The grubs of this species are often destructive to crops in southern Wisconsin.

BROODS OF MAY BEETLES

For the districts bounded roughly by the latitudes of northern Kentucky and southern Minnesota, and from South Dakota on the west to Connecticut on the east, most of the injurious and abundant

FIGURE 4.—A bluegrass meadow seriously damaged by white grubs.

species have a 3-year life cycle. Broods occur, however, in each year of the 3-year cycle, and these have been designated as broods A, B, and C, respectively. Brood A (fig. 5) is by far the most abundant of all known broods and is the one referred to in the years previously mentioned. The second brood (brood B) is of little consequence at present. The third brood, known as brood C (fig. 6), is abundant in comparatively small districts.

FIGURE 5.—Map showing districts of greatest abundance of brood A of white grubs. The extent of these districts and the amount of damage will vary somewhat from one outbreak to another.

LIFE HISTORY AND HABITS

At Lafayette, Ind., all the commoner species of May beetles have been reared from egg to adult. There the life cycle is 3 years, except in the case of several less important species. In the latitude of northern Wisconsin, where grubs of May beetles are destructive to young conifers, the cycle is 4 years, and in the southern latitudes of Texas and the Carolinas the period from egg to adult seems to be 2 years for most

species. The grubs of all the common species occurring at Lafayette, Ind., and northward change to adults late in the summer and early in the fall, pass the winter in the soil as beetles, and emerge the following spring. In several species occurring in the latitude of southern Indiana and southward—species which appear late in the season and after the early-appearing May beetles have almost disappeared—pupation and subsequent emergence of the adults take place in the spring instead of in the fall.

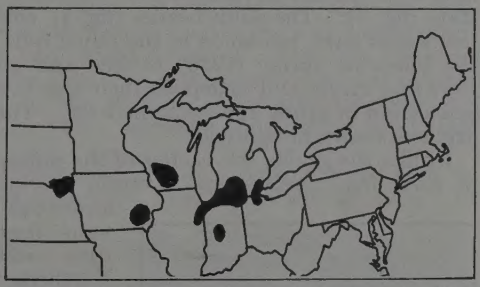

FIGURE 6.—Map showing districts of greatest abundance of brood C of white grubs.

A résumé of the life cycle of the injurious generation of 1933 is as follows: Eggs (fig. 7) deposited by the female beetle in the spring of 1932 hatched 3 or 4 weeks later, and the young grubs fed the first season on decaying and living vegetable matter in the soil. As winter approached they protected themselves from the cold by burrowing deeper into the ground, remaining there inactive until the spring

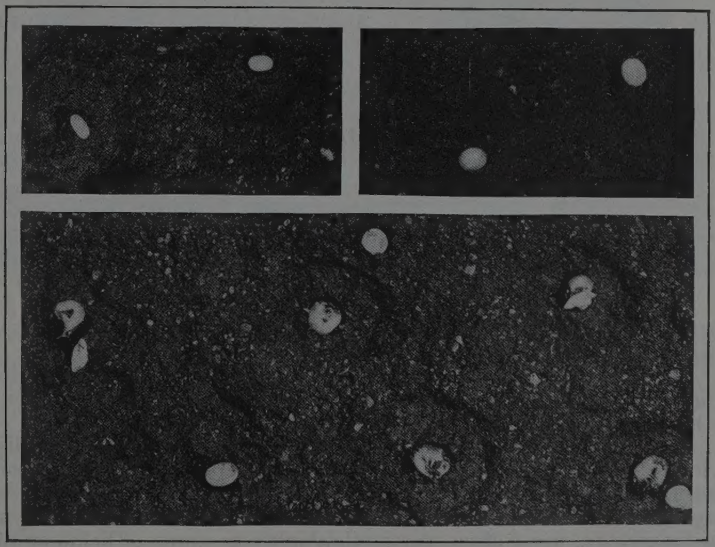

FIGURE 7.—Eggs of May beetles in their natural cells: Upper left, immediately after deposition; upper right, 6 or 7 days later; below, white grubs hatching. About two times natural size.

of the following year (1933), when they returned to a position near the surface, feeding on the roots of such crops as were available. In this the second year they did the maximum damage. In the fall they again went deep into the soil, returning in the spring of 1934 near its surface, where they fed as before on the plant roots until

about June.[2] Thus they passed 2 full years in the grub stage in the soil, and during this time they molted twice previous to molting at the completion of the feeding period (fig. 8). They then prepared oval earthen pupal cells in the ground, became more or less inactive, and later shed the last larval skin and changed to the pupa or true dormant state (fig. 9). The adult beetles (fig. 3), emerging from these pupae a few weeks later, remained in the pupal cells over winter and emerged the following spring (1935) to feed and mate in the foliage of the trees and shrubs and to deposit their eggs in the soil for the destructive generation of grubs appearing in 1936. The usual life cycle of white grubs is shown in figure 13.

Unlike the grubs, the beetles of the different species differ as a rule in their food preferences. Certain species feed almost exclusively on the oak, others prefer the ash, and some feed indiscriminately. The trees ordinarily fed upon in the Northern States are the oaks (bur oaks in preference to red and black oaks), hickory, poplar, elm, willow, locust, hackberry, ash, and walnut. In certain localities pines seem to be the preferred food. At Columbia, S. C., two species were found feeding mainly on the loblolly pine, but in Alabama these same two and one other species were observed to prefer the foliage of longleaf pine.

FIGURE 8.—A full-grown white grub. One and one-half times natural size.

In the latitude of Indiana May beetles first appear about April 25 or May 1 and are present until about July 1 to 15, the period of greatest abundance being from May 15 to 31. In more southern latitudes they appear about a month earlier and in more northerly regions about that much later. At dusk they swarm to trees and other plants and remain there feeding and mating until just before dawn, when they reenter the soil, only to reappear the following evening.

When abundant, the beetles are capable of defoliating farm wood lots, (fig. 10). At such times they are often attracted in great swarms to street lights.

The beetles (fig. 3) prefer to deposit their eggs in the immediate vicinity of timber, in ground covered with vegetation, usually choosing for this purpose the more elevated areas. Their preference in egg laying has an important bearing on control practices, for the grubs ordinarily are most abundant in the higher portions of fields of timothy and bluegrass sod near wooded tracts or in any ground which was in one of these crops or in small grain during the previous year or was covered with vegetation, except clover, during the flight of the beetles. Lawns sometimes become very heavily infested with grubs, the short,

[2] Grubs sometimes do not feed during the third year of their cycle, but remain more or less inactive until time of pupation.

dense growth of grass affording the best conditions for egg laying. Sometimes the grass is completely destroyed and can be rolled back like a carpet (fig. 11). In the case illustrated, as many as 11 grubs were found in 1 square foot of soil.

The eggs (fig. 7) are pearly white. When first laid, they are elongate, measuring about one-tenth inch in length, but 6 or 7 days afterward they become swollen and almost spherical. They are deposited in the soil at depths ranging from 1 to 8 inches, within oval cavities in the center of balls of earth, the particles of earth forming the balls being held together by a glutinous secretion supplied by the female beetles.

For a short time after hatching, the very young grubs feed on decaying vegetation; when numerous, they attack living roots. In

FIGURE 9.—White grub pupa in cell. One and one-half times natural size.

one instance young grubs only about 2 months old were observed damaging timothy fields. The grubs do the greatest injury while in their second year, and in their third year sometimes damage early plantings.

GRUBS LIKELY TO BE MISTAKEN FOR COMMON WHITE GRUBS

A common erroneous belief is that the white grubs of the field and the white grubs often found in manure heaps and rotten logs are identical. The grubs of May beetles are not known to breed in manure or refuse of any kind. The most common grubs found in manure in the Northern States are the immature forms of certain brown beetles which, like the May beetles, frequent lights but, unlike the latter, do not feed on plant foliage. The grubs of May beetles (fig. 12, *a*) may be distinguished from manure grubs (fig. 12, *b*)

FIGURE 10.—Defoliation of bur oak wood lot by May beetles.

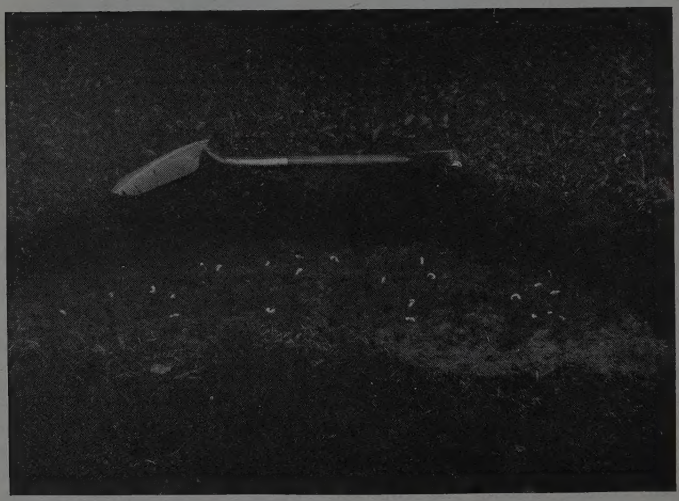

FIGURE 11.—A piece of sod in a lawn overturned to show the white grubs underneath.

and most others by having a double row of more or less conspicuous spines along the middle line on the under side of the last body segment.

Another grub commonly mistaken for that of a May beetle is the young of the green June beetle, *Cotinis nitida* (L.), which frequently has been reported as indirectly injuring grass and other vegetation, including alfalfa, in the Southern States and as far north as Long Island, N. Y., along the Atlantic coast. The grub of the green June beetle seems to prefer soils more or less heavily fertilized with animal manures, and, quite unlike the common white grubs, it makes definite burrows that usually open at the surface and which it may inhabit continuously for longer or shorter periods. Again, this grub may be distinguished from the true white grubs by its general appearance and especially by its peculiar and characteristic habit of crawling on its back when placed on the surface of the ground. These grubs are much less injurious to field crops than are the true white grubs.

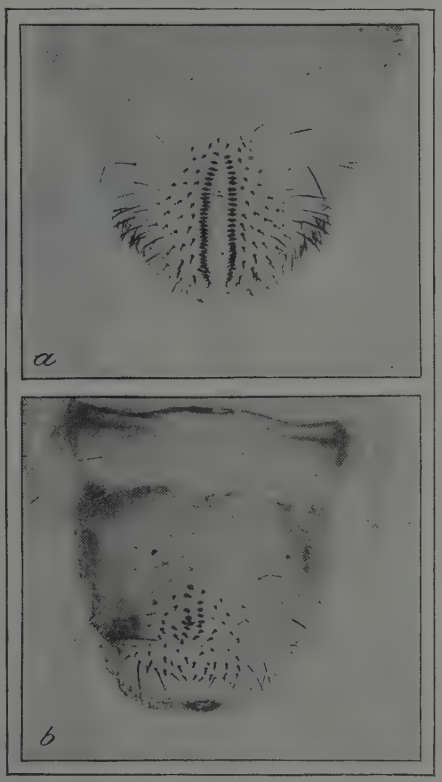

FIGURE 12.—Last segments of the larvae of (*a*) a common white grub and (*b*) a grub frequently found in manure. About eight times natural size.

NATURAL ENEMIES

The white grubs and May beetles are preyed upon by numerous birds, mammals, and insects. Among these probably the most important are birds, especially the crows and grackles and, in some localities, gulls. Fields of timothy sod have been literally overturned by crows in their search for grubs, and in some fields the grubs were almost exterminated by them. Grackles have often been observed following the plow in infested fields, eagerly picking up every grub that was unearthed. The Bureau of Biological Survey has found these insects in the stomachs of 98 species of birds, 11 of mammals, and 2 of toads. It has been observed that the opossum and mole persistently feed on various species of white grubs.

FIRST YEAR
APRIL
MAY
JUNE
JULY
AUGUST
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MARCH
Beetles emerging feeding on leaves, mating, laying eggs.
Eggs laid in soil covered with vegetation
Grubs hatch, feeding first season on decaying vegetation and roots.
Plow line.
Grub in winter cell too deep to be reached by plow.
SECOND YEAR
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MARCH

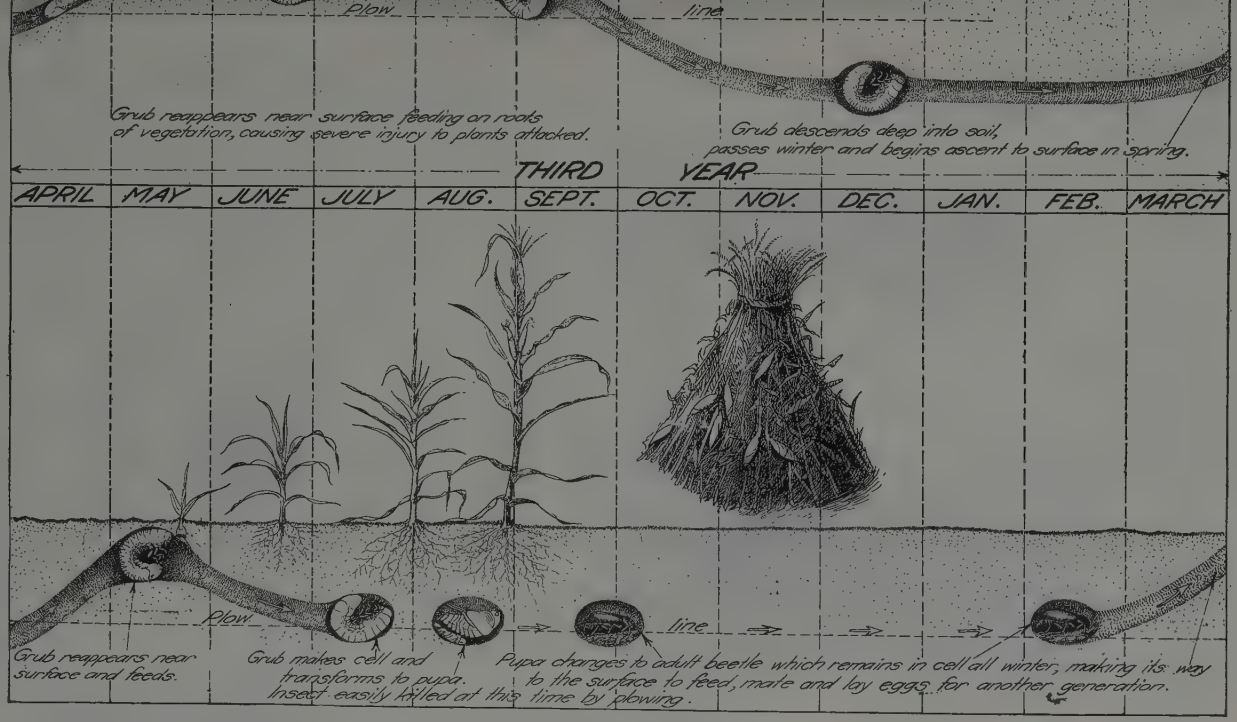
plow
line
Grub reappears near surface feeding on roots of vegetation, causing severe injury to plants attacked.
Grub descends deep into soil, passes winter and begins ascent to surface in spring.
THIRD YEAR
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MARCH
plow
line
Grub reappears near surface and feeds.
Grub makes cell and transforms to pupa. Insect easily killed at this time by plowing.
Pupa changes to adult beetle which remains in cell all winter, making its way to the surface to feed, mate and lay eggs for another generation.

FIGURE 13.—Diagram illustrating the usual life cycle of the species of white grubs commonly injurious in the Central West and showing the periods when they may be killed by plowing.

All farm fowls are fond of these insects and where possible should have the run of infested fields at plowing time. The turkey especially is valuable in this respect.

Among native mammals that feed on the grubs the skunk is probably the most valuable, and, indeed, some farmers have gone so far

FIGURE 14.—Cocoon of a wasp, *Tiphia* sp., a parasite of the larvae of May beetles. About two and one-half times natural size.

FIGURE 15.—Cocoon of a wasp, *Elis* sp., a parasite of the larvae of May beetles. About two and one-half times natural size.

as to attribute the increase in these insects to the decrease in the number of skunks. The common mole is also known to be a great feeder on white grubs.

Several fungous, bacterial, and animal-parasite diseases have been reported as attacking the grubs and beetles, and it is highly probable that when conditions are favorable these serve as valuable natural checks. Among the more important parasitic and predacious insect enemies of the grubs are the larvae of certain wasps and robber flies. The wasp larvae, when full grown, form light-brown woolly (fig. 14) or dark-brown smooth (fig. 15) cocoons in the soil. These are frequently turned out by the plow in fields badly infested with grubs. The robber fly larvae attacking white grubs are slender and shiny white and about an inch and a half long when full grown (fig. 16). They

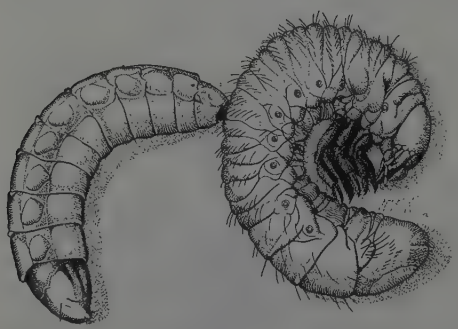

FIGURE 16.—Larva of the robber fly *Promachus vertebratus* attacking a white grub. About one and one-half times natural size.

require 3 years to complete their life cycle. The adult robber fly is predacious on other insects. Certain parasitic flies (fig. 17) attack only the beetle, depositing their eggs within its body as it flies from tree to tree. The larva hatching from the egg gradually kills the beetle.

METHODS OF CONTROL

The general farm practices recommended in this bulletin are preventive rather than remedial. Although there are no satisfactory means of destroying the grubs present in large fields of growing crops, certain cultural and other practices, if carefully carried out, will greatly reduce the damage in succeeding years.

UTILIZING HOGS AND POULTRY TO DESTROY GRUBS

Hogs are very fond of white grubs and May beetles, and under some conditions may be utilized to rid infested areas of this pest (figs. 18

FIGURE 17.—*Pyrgota undata*, a fly parasite of adult May beetles. About two times natural size.

and 19). The percentages of fats and proteins found in white grubs compare favorably with those in corn, although in carbohydrates the insects are deficient. This would indicate that the feeding of corn in connection with pasturing hogs in grub-infested land is desirable where it does not interfere with the control of other insects, such as the European corn borer, *Pyrausta nubilalis* (Hbn.). Fields should not be hog-pastured oftener than once in 3 years, however, because the animals might become infested with the giant thorn-headed worm, a parasite of swine. White grubs serve as intermediate hosts of this worm.

Poultry can well be allowed the run of the fields during plowing or cultivation, since their effectiveness in controlling white grubs has been frequently demonstrated.

ROTATION OF CROPS

To avoid white grub injury certain crop rotations are especially important. A rotation of oats or barley, clover, and corn has proved

satisfactory in some sections. The rotating should be so arranged that during the spring, in which the greatest beetle flight is expected, the maximum acreage will be in a pure stand of clover and the minimum acreage in timothy and small grain. Ground that is in cleanly cultivated corn or has a heavy stand of pure clover during the year the beetles are flying will contain few grubs, since the beetles ordinarily do not seek such land for laying their eggs but prefer land that is in small grains, bluegrass, or timothy or covered with weeds. Land that is in oats, barley, or wheat during the flight of the beetles may contain many grubs, so it should be followed by a planting of clover, which is one of the least susceptible crops. Clover sometimes winterkills badly in southern Wisconsin, northern Illinois, and similar latitudes. There is reason to believe that this is usually due to lack of

FIGURE 18.—Hogs rooting for grubs in a cornfield.

vigor. An application of superphosphate will ordinarily increase the vigor sufficiently to enable the clover to survive the winter. **Where hogs can be pastured on the land the fall previous to planting, less regard need be had for the selection of crops, since a thorough pasturing by hogs will practically eradicate the grubs.**

LATE-SUMMER OR EARLY-FALL PLOWING

Where it is impractical to pasture hogs in an infested field or to follow the previously described methods of rotation, some good can be accomplished by plowing the ground late in the summer or early in the fall. Plowing previous to the time the grubs go deep into the ground to pass the winter will destroy many of them and should be practiced whenever possible, but it should not be considered an efficient remedy. Ordinarily the best time to plow to kill grubs is during the latter part of August or early in September for areas in the latitude of southern Wisconsin and during the latter part of September for more southerly

regions of the Central West. The main point to be remembered is to plow before the grubs go below the plow line.

Summer and fall plowing done in the year the grubs are changing to beetles is of special value in some areas. Every piece of ground known to have contained grubs in their injurious stage the previous year should be plowed as soon after July 15 as possible, and the sooner this is done after that date the more thoroughly will the pests be destroyed. A plow that breaks up the slice as it is overturned should be used; or, if this is not possible, the ground should be deeply disked after it has been plowed, so as to break up the soil and disturb the insects in it.

FIGURE 19.—Grass in foreground uprooted by hogs in search of May beetles that had fed on the foliage of the walnut trees.

If chickens are available when a grub-infested field is being plowed, harrowed, or cultivated, they should have the run of the field.

COLLECTING THE GRUBS AND BEETLES

Where the grubs are numerous and cheap labor can be had, collecting them after the plow is a practical measure. In Europe children are often employed to gather grubs in this manner and to collect the beetles.

In collecting beetles from food plants, large cloth sheets are placed under the trees and the trees are then jarred; or, in the case of large trees, individual branches may be shaken by means of a long pole provided with a hook at its end. The beetles are then gathered up from the sheet and put into containers; afterwards they are killed with boiling water and fed to chickens or pigs. As a rule beetles are most abundant on such trees as the oak, walnut, poplar, hackberry, willow, ash, and elm. Collections should be made early in the morning before daylight, when the beetles are easily jarred from the foliage. It is essential that collecting be begun as soon as the beetles appear in the spring—that is, before they have begun to lay their eggs. Each

female beetle destroyed early in the season before her eggs are laid means the destruction of from 50 to 100 grubs which she might have produced.

Light traps and bait traps have not proved satisfactory as a means of controlling May beetles, the prime objection to their use being that they attract principally the males.

SPRAYING

The trees on which the beetles feed can sometimes be effectively sprayed with lead arsenate or similar arsenical. Ordinarily, however, this is impractical, because the trees are usually large and the areas to be treated are extensive, necessitating the use of large and expensive power sprayers. Small, isolated trees or shrubbery upon which the beetles are likely to feed may be protected from injury if sprayed with a mixture of 2 pounds of lead arsenate, 1 pound of wheat flour, and 25 gallons of water, one of the smaller types of sprayers being used to apply the poison.

CONTROL OF WINGLESS MAY BEETLES

In some parts of the South, as in southern Texas, certain species of wingless May beetles are sometimes prevalent and inflict damage on field and garden crops. Since these beetles are unable to fly, but crawl from field to field, they are amenable to control by methods entirely impracticable in the case of the winged species. It has been found possible to poison them very successfully by means of a poisoned-bran mash. Where an outbreak of these beetles originates in a field, this should at once be treated by distributing a bran mash prepared as follows:

Wheat bran	pounds	20
Paris green	do	1
Sirup	quart	1
Lemons	number	3

Water sufficient to dampen the mixture thoroughly may be added where desirable. The fruit should be ground and added to the bran and paris green after these have been thoroughly mixed.

This bait should be scattered broadcast, at the rate of from 7 to 10 pounds to the acre, during the early hours of the evening, just before dark. Where the beetles are moving from one field to another it is easy to trap them by plowing deep furrows across the path of their advance. Such furrow traps should have their bottoms smoothed with a shovel, but the sides should be left loose so as to hinder the beetles from climbing out of the ditch. If post holes are then dug in the bottom of the furrow at intervals of 15 to 20 feet, the beetles will fall into them and may be destroyed with kerosene or crushed with a heavy stick. It has been found useful to scatter the poisoned bait along the borders of the furrow, as this seems to add to the percentage of kill.

CONTROL OF WHITE GRUBS IN LAWNS AND GOLF LINKS

Although, because of the expense involved, it is impracticable to use soil insecticides on pasture land or on that devoted to field crops, their use on lawns and golf links may be found profitable. Kerosene emulsion and carbon disulphide emulsion have given good results

for the destruction of white grubs in the soil. Carbon disulphide emulsion is apparently the more satisfactory where the equipment and materials are available.

USE OF KEROSENE EMULSION

Kerosene emulsion has been recommended repeatedly as an effective grub insecticide. It is satisfactory against grubs if thoroughly applied where the grubs are near the surface and then washed well into the soil by heavy sprinkling. Watering washes the emulsion from the grass and prevents burning and at the same time permits the insecticide to penetrate more thoroughly into the soil. For small areas, an ordinary sprinkling-can type of nozzle or rose nozzle may be used, so that the lawn can be uniformly drenched in the shortest possible time.

Kerosene emulsion is prepared as follows: One-half pound of hard soap or 1 quart of soft soap, preferably fish-oil, rosin-soda, or rosin-potash soap, is dissolved in 1 gallon of boiling water, and while the mixture is hot, 2 gallons of kerosene is added and the mixture thoroughly emulsified. This may be done most easily and thoroughly by churning it for about 10 minutes with a spray pump, the nozzle being turned back into the liquid. When thoroughly emulsified the preparation will have the consistency of thick cream, and the oil will not separate. **Danger of injuring plants is great if the mixture is not well and thoroughly made.** For a 7½ percent (about 7.14 percent by volume) emulsion add 25 gallons of water to the stock solution previously described, and mix thoroughly. It is desirable to use soft water both for the stock and for diluting, but where this is not obtainable the water should be softened by adding lye or sal soda.

USE OF CARBON DISULPHIDE EMULSION [3]

An emulsion of carbon disulphide with soap and water has shown high efficiency as an insecticide against white grubs in general. The emulsion may be prepared as follows:

	Parts by volume
Rosin fish-oil soap (cold water soluble)	1
Water	3
Carbon disulphide	10

Place the soap and water in a wooden churn or an ice-cream freezer and turn the handle for a few minutes in order to obtain an even mixture. Add the carbon disulphide to the mixture in the machine and turn the handle for 2 minutes, or until the mixture becomes creamlike and thoroughly emulsified.

Add 1 quart of this mixture to 50 gallons of water and apply to the infested lawn at the rate of 3 pints to the square foot of surface. For small areas the liquid may be applied with an ordinary sprinkling can. The application should be made until danger of run-off or puddling is imminent, and allowed to soak into the ground before the remainder of the allotted quantity is applied. Great care should be taken to treat every square foot of turf. It is also essential to keep the lawn moist for several days prior to the application of the insecticide, so as to keep the larvae feeding near the surface, where

[3] Recommendations adapted in part from Technical Bulletin 478, U. S. Department of Agriculture, The Use of Carbon Disulphide Against the Japanese Beetle.

they can be reached by the emulsion. Walking or tramping over treated lawns should be avoided the first day after the treatment so as not to injure the turf.

As the cost of this treatment is rather high, it may not be found practicable except for highly valued lawns or golf greens. **The same general care as regards fire risk should be taken in handling carbon disulphide as is necessary with gasoline.**

In attempting to apply insecticides for white grubs, especially on golf links, care should be taken to differentiate between the work of these pests and that of the grubs of the green June beetle. The grubs of the latter insect are often present in lawns and on the links but do not attack the roots of the grass at all. They are troublesome principally because of the large quantities of earth they throw up at the mouths of their burrows, especially late in the summer and in the fall, thus interfering with the play and covering the grass with mud during damp weather. These grubs become much larger than the white grubs and construct deep vertical burrows in which they hide throughout the late summer, fall, and winter. While deep in the ground they cannot be reached effectively with insecticides, but in midsummer, when they are near the surface and therefore more accessible, they yield to the control methods advocated for white grubs. Undiluted carbon disulphide when injected into the holes of the grub of the green June beetle gives excellent results. The kerosene emulsion mixture mentioned in previous paragraphs likewise has given excellent results against this grub.

USE OF LEAD ARSENATE [4]

If it is undesirable to remove the sod, the grubs in the soil can be killed by the application of lead arsenate to the turf at the rate of 1 pound to 100 square feet of area. To obtain a more uniform distribution it should be mixed with a small quantity of sand or dry soil at the rate of 1 pound of lead arsenate to 1 peck of sand or dry soil.

In constructing a new turf on infested soil, the lead arsenate treatment should be given at the time the seedbed is prepared; if the new turf is on soil free from grubs, the treatment should be given after the seed is sown. If the grass is sown late in the summer, the treatment should be given the following spring. A lead arsenate treatment of turf is usually effective for a period of 5 years.

After lead arsenate has been applied to the turf, the normal operations of mowing, watering, and fertilizing may be carried on as usual. Fertilizers such as well-rotted manure, ammonium sulphate, and bonemeal may be used on treated turf, but lime should be used only when necessary to correct the acidity of the soil.

Lawns destroyed by grubs should be resodded or reseeded, the old sod being first removed and the grubs gathered by hand or killed with one of the insecticides mentioned elsewhere in this bulletin. If poultry, especially turkeys, are allowed the run of the ground as the old sod is being removed, they will do the work in a thorough manner if no poison has been used. Where the infestation is slight, a liberal application of a commercial fertilizer will assist the grass in overcoming the injury done by the grubs.

[4] For more detailed information on the control of white grubs in lawns, see Circular 403, U. S. Department of Agriculture, Preventing Injury from Japanese and Asiatic Beetle Larvae to Turf in Parks and Other Large Areas.

So far as known, no damage to native birds has been caused by a lead arsenate treatment of turf. There is also no evidence that domestic animals have been poisoned where care was taken in applying the treatment as directed. Lead arsenate, however, is poisonous to man and animals and should be handled with great care. Avoid inhaling the dust and protect the hands.

CONTROL METHODS TO BE ADOPTED FOR ALL STAGES OF THE WHITE GRUB

SMALL GRUBS ABUNDANT IN THE FALL OR SPRING

Where small grubs are found in the fall or spring, damage is likely to occur during the approaching summer, as the grubs will become large enough to be destructive to live roots. Infested land should be plowed before October 1, as this destroys the young grubs. Sow land to small grain or clover. Do not plant corn or wide-row crops on such land. Pasture hogs on infested ground and allow chickens to run in fields while cultivation proceeds.

LARGE GRUBS ABUNDANT IN THE FALL OR SPRING

When large grubs are abundant in the fall or spring, these insects are about to transform to the pupa stage. Such grubs may be expected to inflict some damage, but by June 15, or soon thereafter, they cease feeding and prepare to become pupae and beetles. Land infested in this manner should be plowed before October 1. Where the ground is infested with large grubs in the spring it should be plowed as soon after July 15 as practicable. Pasture with hogs when that is possible.

BEETLES OR PUPAE IN GROUND IN THE SUMMER

Where pupation takes place in the upper 6 inches of soil, plow the land thoroughly, so as to break the clods, subsequent to July 15, the sooner after that date the better. This will kill the pupae and expose the beetles to their enemies. Pasture with hogs when that is possible.

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